3 - 41 Swift Heavy Ions Irradiation Acts as a Size Filter to Ag Nanoparticles Embedded in Silica Glass

Yang Yitao, Zhang Chonghong, Song Yin, Gou Jie, Zhang Liqing, Meng Yancheng
Zhang Hengqing and Ma Yizhun

The swift heavy ions (SHI) irradiation using a tool for the ion-beam-shaping technique has attracted much attention in recently years, which can transform spherical metal nanoparticles (Nps) to prolate spheroids, nanorods or nanowires, with the elongation along the beam direction[1]. In this study, we show that SHI irradiation can also act as a size filter to Ag Nps embedded in silica glass. In experiment, Ag Nps were introduced into silica glass by Ag ions implantation. Subsequently, 73 MeV Ca ions were used to irradiate the samples contained Ag Nps to the fluences of 0.4, 1.0 and 3.8 10^{14} ions/cm^2. The direction of incident ions is perpendicular to sample surface. TEM micrograph for Ag ions implanted sample (Fig. 1a) reveals that Ag Nps with wide size dispersion distribute in the depth ranging from 40 to 220 nm, and the largest Nps distribute around the depth of 80 nm. However, Ag Nps smaller than ~ 2.0 nm in shallower or deeper region disappear after Ca ions irradiation. As a result, only Ag Nps larger than ~ 2.0 nm survive and distribute in a narrow region (Fig. 1b), moreover, the size dispersion of Ag Nps is also reduced. High energy Ca ions irradiation seems to act as a size filter, Nps smaller than ~ 2.0 nm are filtered.

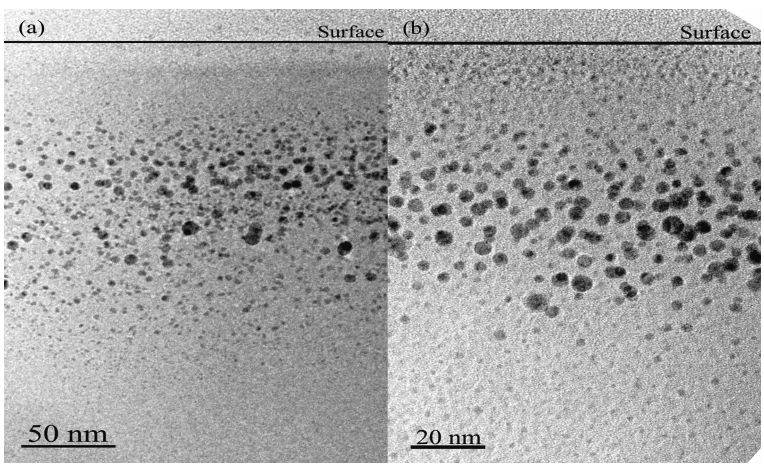

Fig. 1 Cross-section TEM graphs for (a) the sample implanted with 200 keV Ag ion, (b) the sample embedded with Ag Nps and irradiated with 73 MeV Ca ions to fluence of 1.0×10^{14} ions/cm^2.

Generally, for metal Nps larger than a critical size (such as ~ 6-7 nm for Pt NPs), the spherical Nps transform to prolate spheroids, nanorods or nanowires when both energy and fluence of incident ions are higher than the corresponding thresholds for Nps deformation[2]. For Nps smaller than the critical size, the shape of Nps does not change during irradiation, however, Nps diameter decreases in size with increase of irradiation fluence until they are dissolved in matrix[3]. The deformation of Ag Nps with diameter 15 nm in silica was observed after irradiation with 10 MeV Kr ions (S_e~ 3.6 keV/nm in silica)[4]. However, in this study the deformation of Ag Nps is not observed after 73 MeV Ca ions irradiation (S_e~ 5.0 keV/nm in silica), only dissolving of Nps smaller than ~ 2.0 nm is observed. From the TEM micrograph (Fig. 1a) the largest Ag Nps before irradiation is only ~ 5.0 nm, thus the reason could be that Ag Nps is below the critical size for deformation.

References

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